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SEISMIC DATA LABORATORY
DATA SERVICES REPORT NUMBER 5

21 July 1965

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By

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Under

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INTRODUCTION

This is the fifth of a series of reports which catalog seismic data and digital programs generated and collected by the Seismic Data Laboratory (SDL). The following items are described in this report and are available to other users:

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III. Digitized data

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VI. Amplitude, period, and arrival times of phases from 50 U.S. nuclear explosions

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Space is reserved and viewers are provided for persons who wish to study data at the SDL. Those who want to visit the Seismic Data Laboratory, or request data, should direct their request to:

Headquarters, USAF/AFTAC
VELA Seismological Center
Washington 25, D. C. 20330

Attn: Project Officer, Seismic Data Laboratory

I. Digital Programs in Use at SDL

Copies of the source deck, program listings, and program write-ups are available for the following:

A. Correlation and Regression Analysis

1. AUTOCOR AUTO-CORRELATION ANALYSIS

FORTRAN. Given a series of values x(1), x(2),...x(N), this program will compute the product-moment correlation coefficient (auto-correlation) between successive terms, where the lag(k) goes from 0,1,..L. Space required = 1,781 locations.

2. MANYCOR CORRELATION ANALYSIS

FORTRAN. Given M sets of data, this program calculates the mean, corrected sum of squares, variance, and standard deviation for each set. Also computes the regression coefficients, (linear) correlation coefficients, and the standard error of estimate for all possible combinations of sets of data. Space required = 9,153 locations.

3. BIMD MULTIPLE REGRESSION AND CORRELATION ANALYSIS

FORTRAN. This program performs multiple regression and correlation analysis on a maximum of 30 variables. The maximum number of independent variables that can be deleted at one time is 28, the number of replacements is not limited. The program can make a log base 10, square root, or square transformation on any or all of the variables as desired. 17,572 unique storage locations, 4,958 common storage locations.

4. AUTOV AUTOCOVARIANCE SUBROUTINE

FORTRAN. Computes the autocovariance of a series of N terms with L lags.

5. CRSCOV AUTO- AND CROSS-VARIANCE SUBROUTINE

FORTRAN. Given two series X and Y each of N points, computes autocovariance of X and Y and cross-variance of X to Y and Y to X.

6. LINDISC LINEAR DISCRIMINATOR

FORTRAN. Computes a linear function of N variables measured on each individual of two groups, which in a certain sense serves as a best index for discrimation between the two groups. The criterion of "best" is that the difference between the mean indices for the two groups divided by a pooled standard deviation of the indices should be as large as possible.

7. FRENORM FREQUENCY AND TEST OF NORMALITY

FORTRAN. Given digitized seismic noise data, this routine investigates the distribution of seismic noise amplitudes.

8. ANALVR ARRAY SIGNAL ANALYSIS OF VARIANCE

FORTRAN. Uses of the analysis of variance method to compute and output a function of time which measures the likelihood of a signal being present in the data from an array of seismometers.

B. Time Series Analysis

1. TUKEY TUKEY SPECTRUM, CROSS SPECTRA AND POWER SPECTRA

FORTRAN. This time series analysis program contains three basic subroutines. The first two, filter and removal of trend, prepare the data for the spectrum analysis subprogram. TUKEY SPECTRUM computes for the two simultaneous time series, the cross (co- and quadrature-) spectra, and the two power spectra. Phase and coherence are calculated.

2. FOURTR FOURIER ANALYSIS SUBROUTINE

FORTRAN. Computes the sine or cosine, smoothed or unsmoothed transform of a series of M terms.

3. FOURAN FOURIER ANALYSIS SUBROUTINE

FORTRAN. Given a time series of N points, computes sine transform, cosine transform, modulus A, modulus normed, log A, phase (fraction of a circle), and maximum value of the modulus.

4. FOULAGR I FOURIER-LAGUERRE TRANSFORM

FORTRAN. EXpands a given time function in a series of Laguerre functions, and from the Laguerre expansion computes Fourier amplitude, phase, and power spectra.

5. FOULAGR 2 DIRECT FOURIER-LAGUERRE TRANSFORM

FORTRAN. Given a time series, this program computes and plots on a semi-log or log-log basis, the amplitude, power, and phase spectra. The program prints these quantities along with their Laguerre function expansion, and computes the weighting function in positive or negative time measured at the Laguerre sample points of the given time series.

6. VELQLAG LAGUERRE EXPANSION, FOURIER ANALYSIS

FORTRAN. Computes the Laguerre expansion of surface waves recorded at stations along a profile. From the Laguerre expansion it computes Fourier spectra, and from the Fourier spectra it computes phase velocity, attenuation, and Q as functions of frequency between pairs of stations.

7. FOUTRSAT FOURIER TRANSFORM

FORTRAN. Given a time series of N points, the program computes amplitude, phase, frequency, and a power spectrum with the use of Fourier transforms.

8. FASTFTI FAST DIRECT AND INVERSE FOURIER TRANSFORM

FORTRAN. Computes the direct and inverse Fourier transform of a periodic function.

9. FRAMIS COMPUTATION OF SPECTRA AND PHASE FROM THE LAPLACE TRANSFORM

FORTRAN. Given the parameters in the LaPlace transform, this program evaluates the amplitude spectra and phase of the transformation.

C. Random Number Generators

1. RANDOM FAST RANDOM NUMBER GENERATOR SUBROUTINE

FORTRAN. One psuedo random, floating point number is produced for each call of the subroutine Random (R). The numbers are uniformly distributed in the interval 0 to 1.

2. RANDSET GENERATE RANDOM SUBSETS OF STATIONS

FORTRAN. Given a set of station cards and their heading cards, this program will generate requested subsets of unique stations, printing them out and writing them on tape in a format for direct input to the program LOCATE.

D. Matrix Operations

1. MATINV MATRIX INVERSION WITH ACCOMPANYING SOLUTION OF LIN. EQU.

FORTRAN. Solves the matrix equation AX = B, where A is a square coefficient matrix and B is a matrix of constant vectors. The inverse A**-1 and the determinant of A are also computed. Space required = 505 + N locations.

2. GAUSS 3 MATRIX INVERSION BY GAUSS METHOD

FORTRAN. Inversion of a real matrix is accomplished by the Gauss method with row pivoting and back substitution.

E. Digital Filtering

1. FILPLOT FREQUENCY RESPONSE OF A DIGITAL FILTER

FORTRAN. Computes, prints, and plots the frequency response of a symmetric digital filter, as specified by its coefficients.

2. COEFFT FILTER COEFFICIENTS FOR BAND PASS FILTER

FORTRAN. Given the center of band pass, half-width of band, and roll-off in terms of normalized frequency (frequency times the time increment). and the number of coefficients in half of a symmetric filter. Computes and returns the band pass filter coefficients.

3. FILTER FILTER SUBROUTINE

FORTRAN. Applies given filter coefficients to a series of N points and returns the filtered series.

4. FILDEC DIGITAL FILTER AND DECIMATOR SUBROUTINE

FORTRAN. Filters and decimates a given series of N points with given filter coefficients and returns the filtered and decimated series.

5. ANLGFLTR ANALOG FILTER SUBROUTINE

FORTRAN. This subroutine performs low pass and high pass filtering of digital data in the same way that analog filters do of analog data.

6. POINTFLT DISCRETE LAGUERRE FILTER

FORTRAN. This subroutine accepts one data input at a time and passes this data through a set of recursive filter operations which can be stated either as a time operation or as a frequency operation.

7. RESREC PLOT RESPONSE OF RECURSIVE BAND PASS FILTER

FORTRAN. Computes and plots the amplitude of a recursive phaseless digital filter.

F. Data Retrieval and Manipulation

1. CENTRE CENTER A RECORD SUBROUTINE

FORTRAN. This subroutine centers the record A (I) of N points into the record B(J) of M points and places zeros on both sides.

2. DETRND REMOVAL OF MEAN AND/OR LINEAR TREND

FORTRAN. This subroutine removes the mean only or both the mean and linear trend of a series of N points, and returns the detrended series.

3. SUBSET DATA RETRIEVAL

FORTRAN. Retrieves requested seismograms from a merged data tape. Any retrieved seismogram may be limited by a requested time interval. In addition, the retrieved seismogram may be limited to certain requested channels. The retrieved data is written on a magnetic binary tape and another reel of plotted data is written if requested.

4. EPLIST EPICENTER LISTING

FORTRAN. List the information contained in pre-punched USC & GS epicenter cards for earthquakes satisfying predetermined values for any desired combination of the following variables: latitude, longitude, depth, magnitude, azimuth, and distance.

5. TRAVELT COMPUTER P-ARRIVAL TIMES

FORTRAN. Computes the P-arrival times from seismic events, reported on the PDE cards of the U.S. Coast & Geodetic Survey, to specified stations and lists them together with all the information contained on the PDE cards.

6. SQUASH SCALING ROUTINE

FORTRAN. Finds and returns the maximum and minimum values of a series of N terms and then scales the series with a given maximum absolute value.

7. RANGE MAXIMUM AND MINIMUM VALUE SUBROUTINE

FORTRAN. Finds and returns the maximum and minimum values of a series of N terms.

8. NORMAL NORMALIZE SUBROUTINE

FORTRAN. Computes and returns a normalized series from a given series of N terms.

9. DEPTHMAG RETRIEVAL AND/OR COUNT OF EPICENTERS SUMMARIZED BY DEPTH AND MAGNITUDE

FORTRAN. This program retrieves epicenter information, from punched PDE cards, that meet a certain criteria applied to a number of difference values associated with each epicenter. As epicenters are retrieved, the program summarizes on magnitude and depth.

G. Analog to Digital Conversion Programs

1. ATOD ANALOG TO DIGITAL CONVERSION

160A. Inputs digitized data from the analog to digital converter and writes this data on magnetic tape in a format which can be handled by the CDC 1604 or IBM 7090.

2. LABEL LABEL AND MERGE DIGITAL DATA

FORTRAN. Merges and labels digitized seismograms onto a FORTRAN-62 binary tape, and generates and X-Y plot of each seismogram.

3. LABLIST LIST AND CHANGE LABELS

FORTRAN. Lists the labels of the merged seismogram tapes with the option of changing or expanding any or all of them.

4. TAPE CONVERSION DIGITIZED TAPE CONVERSION

CODAP-1. Generates a FORTRAN format data tape and a plot format tape from a special 160-A binary tape generated by analog to digital conversion. The FORTRAN format tape contains one file per seismic event with the digitized data packed four values per 1604 word with one value from each channel (Z,R,T, timing) in each word.

H. Interpolation and Approximations

1. LAGUER LAGUERRE POLYNOMIAL

CODAP-1. Evaluates the Laguerre polynomial for any real argument X and any order N. 130 238(N-1) microseconds. 24 locations.

2. LEGEND LEGENDRE POLYNOMIAL

CODAP-1. Evaluates the Legendre polynomial for any real argument X and any order N. 123 + 247 (N-1) microseconds. 25 locations.

3. TCHEB TCHEBYCHEV POLYNOMIAL

FORTRAN. Evaluates the tchebychev polynomial for any real argument X and any order N. 109 81 (N-1) microseconds. 16 locations.

4. POLYMUL ROOTS OF POLYNOMIAL EQUATIONS BY MULLERS METHOD

FORTRAN. To find, using Mullers method, all the roots of a polynomial equation having arbitrary complex coefficients.

5. TRAPZ TRAPEZOIDAL RULE INTEGRATION

FORTRAN. Evaluates the integral of F(X)DX for a succession of F(X)S by the trapezoidal rule. Space required = 164 locations. Timing = 850 microseconds average.

6. EXTREM MULTI-DIMENSIONAL EXTREMUM SEEKER

FORTRAN. Computes the maxima, minima, or saddle points for a single function of up to 20 parameters.

7. LSQPOL LEAST SQUARES POLYNOMIAL FITTING SUBROUTINE

FORTRAN. Given X(I), X(1),X(2),...,X(M) and F(I), F(2),...,F(M), where F(I) is the observed dependent variable and X(I) is the observed independent variable, the polynomial Y = B(1) + B(2) *X + ...+B(+1)*X**K is fitted for all degrees of K, from K= 1 to K = K(MAX) with certain options.

8. MINIMIZE MINIMIZE A FUNCTION OF N VARIABLES

FORTRAN. To find a minimum of a function of many variables. The gradient method is used.

I. General Seismic Programs

1. ARRAY LINEAR ARRAY

FORTRAN. Plots the cross-correlation of time shifted seismometer data, given the unshifted seismometer records as input.

2. LOCATE — DETERMINATION OF LATITUDE, LONGITUDE, DEPTH, AND ORIGIN TIME OF A SEISMIC SOURCE

FORTRAN. Calculates, by an interative least-squares process, the latitude, longitude, depth, and origin time of a seismic source, and determines the confidence intervals and joint confidence region for the source coordinates. Compressional wave arrival times from five or more stations are used.

3. GROVEL — GROUP VELOCITY FROM PHASE VELOCITY DISPERSION

FORTRAN. This program takes the phase velocity versus period or frequency points, fits a best least-squares polynomial to these points and uses the polynomial and its derivatives to obtain the group velocity as a function of period or frequency.

4. MOD PV-7 — SURFACE WAVE DISPERSION AND AMPLITUDE

FORTRAN. This program computes for all modes of Love and Rayleigh waves on an elastic halfspace of plane-parallel, homogeneous, isotropic layers, the following: phase velocity, group velocity, and surface orbit as functions of period or frequency; amplitude, the product of vertical wave number times layer thickness, and potentials as functions of depth; average kinetic, potential, and total energy densities, and average horizontal energy flux, corresponding to each layer; and a summation of the energy quantities from the free surface. Provision is made for printer plots of phase and group velocity. Provision is also made for partial decoupling where amplitude is large in certain channels at depth, relative to the surface amplitude.

5. CALIB — MAGNIFICATION CALCULATION USING DIGITIZED SINE WAVE CALIBRATIONS

FORTRAN. Computes the average peak-to-peak amplitude, the magnification, and normalizing factors of a digitized sine wave calibration. The Y factors for each trace may be input or they may be calculated, given specified input parameters.

6. LAGTIME SIGNAL AND NOISE ADDITION

FORTRAN. This program combines a signal and noise onto the same data channel at varying signal-to-noise ratios. A tape of the new combination of data is written and a plot tape is formed.

7. MAKARAY ARRAY SIMULATION

FORTRAN. Produces a set of output traces corresponding to any set of element positions desired. A noise background is simulated by selecting ten traces from a set of twenty sample traces, and assigning to each trace an arbitrary velocity, azimuth and relative amplitude. A signal is selected from a set, its velocity and azimuth are chosen and a signal-to-noise ratio is assigned.

8. DISCRETE EVALUATION OF KAUTE EXPANSION COEFFICIENTS

FORTRAN. Expands either a seismic signal or a specified function in terms of a set of orthonormalized exponential functions. Parameters given by the user define the orthonormal functions. The spectrum of the expansion is available as an option.

9. DISTA DISTANCE, AZIMUTH, AND TRAVEL TIME

FORTRAN. Computes the distance in degrees and kilometers, the azimuth, back azimuth, the travel time or arrival time, and the rotations parameters from a specified seismic event to a given station.

II. MIT Geophysics Program Set II

The symbolic decks of this set form an interlocking system of 267 self-documenting (including examples) subroutines written in FORTRAN and FAP. The primary emphasis of these programs is on single and multiple time series analysis.

Additional information about this system of programs can be acquired by requesting "Magnetic Tape Copies of MIT Geophysics Program Set II-Report No. 10."

III. Digitized Data

SDL has 3500 seismograms in its library of digitized data.

Approximately 60 U.S. nuclear explosions and 400 earthquakes have been digitized for various LRSM sites and VELA observatories. A complete list of digitized data is available upon request, but users are encouraged to visit the SDL to ascertain that the requested data is usable.

Digitized data can be punched on cards or written on tape in an IBM compatible format. The data is written in the binary mode at 200 or 556 bits per inch (as specified by the requestor). The tapes contain a variable number of files of 36-bit word binary integers. Each file contains either a vertical or horizontal component from a single station for a specified period of time (up to 13 minutes).

The binary integers range between plus and minus 2048. The data is not necessarily calibrated, but instructions are available for relating digital counts to earth motion at 1 cps.

The sampling rate can be varied, but is normally 20 samples per second. The data is prefiltered to minimize aliasing. The time of the first digital point can be determined to $\pm$ .1 second.

A separate list is furnished with each tape giving the order of the seismograms written on each tape, sampling rate, number of files per seismogram, number of data points per file, time of first point, component identification, event name, recording station, and filter setting used at time of digitization.

IV. U.S. Coast & Geodetic Survey Epicenters

A copy of a BCD tape containing epicenters listed on the PDE cards (January 1960 to date) can be sent to those who furnish a blank digital magnetic tape. Geographic and seismic regions have been computed for each epicenter.

The cards contain:

ORIGIN TIME	MAGNITUDE
LATITUDE	SOURCE OF MAGNITUDE
LONGITUDE	GEOGRAPHIC REGION NUMBER
DEPTH (KM)	SEISMIC REGION NUMBER
	COMMENTS

V. Earthquake Bulletin Data

Earthquake bulletin data from the LRSM teams (February 1962 to date) and the VELA observatories (February 1963 to date) has been written on magnetic tape. Detailed information on card formats is available upon request. Data includes the PDE cards plus all phase information for those stations which recorded the earthquake. Recorded phase arrivals not associated with an epicenter are also on the tape.

VI. Shot Report Data

Data from the following shots has been punched on cards:

AARDVARK
ACOUSHI
AGOUTI
ALLEGHENY
ANTLER
ARMADILLO
BILBY
BOBAC
CASSELMAN
CHENA
CHINCHILLA
CHINCHILLA II
CIMARRON
CLEARWATER
CODSAW
DANNY BOY
DES MOINES
DORMOUSE
DORMOUSE PRIME
FEATHER
FISHER
FORE
HARDHAT
HAYMAKER
HYRAX
KAWEAH
MAD
MADISON
MARSHMALLOW
MERRIMAC
MINK
MISSISSIPPI
PACKRAT
PAMPAS
PASSAIC
PEBA
PLATYPUS
RINGTAIL
ROANOKE
SACRAMENTO
SANTEE
SEDAN
SHOAL
SHREW
SMALLBOY
STILLWATER
STOAT
STONES
WICHITA
YORK

The data on the punched cards includes:

Shot Name
Location
Magnitude
Medium
Recording Station
Phase ID
Arrival Time
First Motion (if picked)
Period
Amplitude
Instrument
Component
Azimuth
Distance

VII. Analog Composite Tapes

Analog composite tapes have been made for approximately 100 nuclear shots and several hundred earthquakes. A composite tape for a given event contains each station calibration, 10 minutes of data recorded at each station before the P arrival, and 10 - 20 minutes of data recorded after the P arrival.